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(11) EP 1 058 421 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

06.12.2000 Bulletin 2000/49

(51) Int Cl.: H04L 12/28, H04L 29/06

(21) Application number: 00304576.0

(22) Date of filing: 01.06.2000

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(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE

Designated Extension States:
AL LT LV MK RO SI

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(54) Dynamic home agent discovery method and system

(57) The present invention is an efficient and improved dynamic home agent discovery algorithm and system to be used in a protocol for Internet or network communications. The present efficient and improved dynamic home agent discovery algorithm and system for a protocol more efficiently uses the wireless access, communications resources, and the network resources. If a failure or error occurs at a home agent (16), the efficient and improved dynamic home agent discovery algorithm and system provide recovery or backup home agent services to the mobile node(s) associated or coupled to the failed home agent. The efficient dynamic home agent discovery algorithm and system encapsulate and integrate communications of the home agents (16) into a single home agent communication. Communication between the mobile node (11) and the home agents (16) is simplified to a single home agent communication. Dynamic home agent discovery processes are performed based on the single home agent communication. Encapsulation is achieved by having each of the home agents (16) maintain a home agent list that contains information about each of the home agents coupled to the home link. Heart beat messages are used to communicate the information between each of the home agents (16). A designated home agent (16) for the home agents receives and processes a single home agent discovery request from the mobile node (11), and a designated home agent (16) for the home agents (16) sends home agent advertisement and communicates and processes a single home agent discovery request to the

mobile node (11).

Dynamic Home Agent Discovery Process

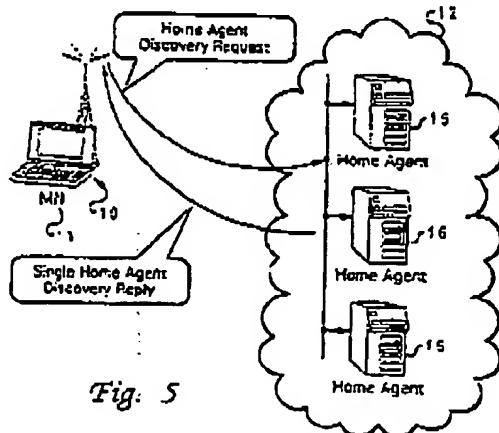


Fig. 5

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Description**BACKGROUND OF THE INVENTION****1. Technical Field:**

[0001] The present invention relates in general to a home agent discovery algorithm and system for a computer protocol and in particular to an efficient and improved dynamic home agent discovery algorithm and system for a computer protocol that provides efficient communications and utilization of resources between a mobile computer system or device and other systems and devices, especially when the mobile computer system or device has moved from one location to another location.

2. Description of the Related Art:

[0002] Computers or computer systems/devices that communicate with each other over the Internet and a home network require the use of a protocol or internal protocol (IP). Figure 1 is a prior art figure of a mobile computer 10 in communications with a home network 12 at one location which is moved to another location that is in communications to the Internet 14. The configuration in Figure 1 requires a base mobile Internet protocol (IP) for providing and routing communications between computer systems and devices, especially when the mobile computer 10 has moved from one location to another location (i.e. moved from being in communication with the home network 12 to being in communication with the Internet 14). Current protocols require the use of dynamic home agent discovery algorithms in order for the mobile node 11 to discover the IP address of its home agent 18. However, inefficiencies and problems exist with current protocols, such as the base mobile Internet protocol (IP), that use present dynamic home agent discovery algorithms.

[0003] In discussing those protocols that use dynamic home agent discovery algorithms, the following terms are generally defined:

[0004] "Mobile Node" is a host or router that changes its point of attachment from one network or sub-network to another network or sub-network. A mobile node may change its location without changing its IP address, and it may continue to communicate with other Internet nodes at any location using its (constant or fixed) IP address, assuming link-layer connectivity to a point of attachment is available.

[0005] "Home Agent" is a router on a mobile node's home network which tunnels datagrams for delivery to the mobile node when it is away from home and maintains current location information for the mobile node. The home agent has three main operations: 1) sending agent advertisement; 2) receiving a home agent discovery request and processing the discovery request; 3) receiving a registration request and processing the regis-

tration request.

[0006] "Foreign Agent" is a router on a mobile node's visited network, which provides routing services to the mobile node while registered. The foreign agent de-tunnels and delivers datagrams to the mobile node that were tunneled by the mobile node's home agent. For datagrams sent by a mobile node, the foreign agent may serve as a default router for registered mobile nodes.

[0007] "Agent Advertisement" is an advertisement message constructed by attaching a special Extension to a router advertisement message.

[0008] "Care-of Address" is the termination point of a tunnel toward a mobile node, for datagrams forwarded to the mobile node while it is away from home. The protocol is able to use two different types of care-of address: a "foreign agent care-of address" is an address of a foreign agent with which the mobile node is registered and a "co-located care-of address" is an externally obtained local address which the mobile node has associated with one of its own network interfaces.

[0009] "Correspondent Node" is a peer which is communicating with a mobile node. A correspondent node may be either mobile or stationary.

[0010] "Home Address" is an IP address, that is assigned for an extended period of time to a mobile node. It remains unchanged regardless of where the node is attached to the Internet.

[0011] "Home Network" is a network, possibly virtual, having a network prefix matching that of a mobile node's home address. Standard IP routing mechanisms will deliver datagrams destined to a mobile node's Home Address to the mobile node's Home Network.

[0012] "Link" is a facility or medium over which nodes are able to communicate at the link layer. A link underlies the network layer.

[0013] "Mobility Agent" is either a home agent or a foreign agent.

[0014] "Mobile Node's Failure Recovery Information" is the minimal amount of information required to recover the mobile node's operation if its serving home agent failed. The mobile node's failure recovery information should contain at least a mobile node's care-of address, mobile node's home IP address, registration lifetime, and registration flags.

[0015] "All Home Agents Multicast Address" is a D class address (multicast address) which is assigned to the set of home agents on the Internet Service Provider (ISP) network. It is recommended for mobile nodes to use this address to access home agents instead of sub-net-directed broadcast address for efficiency reasons.

[0016] Computer networks and Internet links have been in existence for several years. Also, wireless access and communications to these networks and to the Internet have also been in use. However, current protocols that use present dynamic home agent discovery algorithms and systems to handle and deal with communications of mobile computers to the Internet and network, such as base mobile IP, result in various problems and

shortcomings.

[0017] These present protocols that use dynamic home agent discovery algorithms and systems inefficiently use wireless access and communication resources and network resources. For example, prior art Figure 2 and 3 shows a mobile computer 10 with a mobile node 11 that communicates (through the Internet 14 having a relatively low bandwidth) with a home network 12 having a relatively large or infinite bandwidth.

[0012] One inefficiency problem with present protocols that use dynamic home agent discovery algorithms or systems stems from the fact that agent advertisement must be used by the protocol in order to detect motion and location of a mobile node 11. Prior art Figure 2 shows mobility agents, such as home agents 16 or foreign agents, advertising their presence to a mobile node 11 via agent advertisement messages. Each and every home agent 16 advertises its presence to the mobile node 11 as shown in Figure 2. In this example, wireless networks have a set of RF channels, which is used for communication between hosts (i.e. home agents 16) and mobile nodes 11. When a host (i.e. home agents 16) wants to send a packet to a mobile node 11, the mobile node 11 is allocated one of these RF channels. Packet communication between the host (i.e. home agents 16) and the mobile node 11 commences once one of the RF channels is allocated. Many other mobile nodes 11 would also be allocated various RF channels. If multiple home agents 16 are periodically sending agent advertisement messages, where the period between transmission, for example, is one (1) second, then low-optimization of the RF bandwidth would result causing inefficient use of scarce wireless access and communication resources. A similar inefficiency problem with use of network bandwidth also exists on the network side. Thus, inefficient usage of wireless network resources, such as the use of RF channels, results from the present home dynamic home agent discovery algorithms and systems if multiple home agents send agent advertisement messages.

[0019] Another inefficiency problem with current protocols that use dynamic home agent discovery algorithms involves the mobile node 11 having to register and the home agents 16 having to reply to the registration requests. The mobile node 11 registers directly with its home agent 16. However, the mobile node 11 may not know the IP address of its home agent 16, and the mobile node 11 then uses the dynamic home agent discovery algorithms to automatically determine the IP address of its home agent 16. In this case, as shown in prior art FIGURE 3, the mobile node 11 must send a home agent discovery request to each home agent 16 wherein the mobile node 11 sets the home agent subnet-directed broadcast address of the mobile node's home network 18 and sends the home agent discovery request to each home agent 16. All of the home agents 16 receiving the home agent discovery request must reply as shown in prior art FIGURE 3. If the mobile node 11 does not have

a registered home agent 16, then the mobile node 11 must select and register with a home agent 16. Each home agent 16 already having a broadcast destination address must reject the mobile node's registration request and return a rejection registration reply indicating its unicast IP address for use by the mobile node 11 in future registration attempts. The receipt by the mobile node 11 of all of the replies from the home agents 16 results in execution time inefficiencies, more complex processing, and improper utilization of radio frequency (RF) and network bandwidth.

[0020] A further problem relates to when a home agent 16 fails. If a home agent 16 fails, then a back up home agent 16 to take over the operations of the failed home agent 16 in servicing the respectively registered mobile node(s) 11 presently does not exist. Therefore, if a home agent 16 fails, then inconvenience and loss of service to the mobile node(s) 11 results. Also, if a home agent 16 fails, then time-consuming recovery operations need to be implemented or loss of operation and service by the home agent 16 (no way of recovery from failure or error) results. A system and method for recovering from such a failure or error of a home agent 16 or a backup system for such a failure or error occurrence presently do not exist.

SUMMARY OF THE INVENTION

[0021] The present invention is an efficient and improved dynamic home agent discovery algorithm and system to be used in a protocol for Internet or network communications. The present efficient and improved dynamic home agent discovery algorithm and system for a protocol more efficiently uses the wireless access, communications resources, and the network resources. If a failure or error occurs at a home agent, the efficient and improved dynamic home agent discovery algorithm and system provide recovery or backup home agent services to the mobile node(s) associated or coupled to the failed home agent. The efficient dynamic home agent discovery algorithm and system encapsulate and integrate communications of the home agents into a single home agent communication. Communication between the mobile node and the home agents is simplified to a single home agent communication. Dynamic home agent discovery processes are performed based on the single home agent communication. Encapsulation is achieved by having each of the home agents maintain a home agent list that contains information about each of the home agents coupled to the home link. Heart beat messages are used to communicate the information between each of the home agents. A designated home agent for the home agents receives and processes a single home agent discovery request from the mobile node, and a designated home agent for the home agents sends home agent advertisement and communicates and processes a single home agent discovery request to the mobile node.

[0022] The above as well as additional features and advantages of the present invention will become apparent in the following detailed written description.

[0023] It is thus possible to provide an efficient and improved dynamic home agent discovery algorithm and system to be used in a protocol for Internet or network communications.

[0024] Advantageously, the present invention further provides a protocol that has a more efficient and improved dynamic home agent discovery algorithm and system that overcomes the problems and disadvantages of the prior art algorithms. The efficient and improved dynamic home agent discovery algorithm and system allows the implementation of a protocol that is more efficient in using the wireless access, communications resources.

[0025] Additionally, the present invention provides an efficient and improved dynamic home agent discovery algorithm and system that provide a way of identifying and recovering from a failure or error that occurs at a home agent or a backup system and method that is able to be implemented when a failure or error has occurred at a home agent to provide recovery or backup home agent services to the mobile node(s) in the event of a failure or error occurrence.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0027] Figure 1 is a prior art diagram showing an overall configuration of a mobile computer that is able to move from one location to another location and that communicates over the Internet and a home network with other systems or devices wherein the configuration requires the use of a protocol that uses a dynamic home agent discovery algorithm or system for such communication.

[0028] Figure 2 is a prior art diagram showing the home agent advertisement process for home agents wherein this advertisement process is implemented by a dynamic home agent discovery algorithm or system for a computer protocol.

[0029] Figure 3 is a prior art diagram showing the home agent discovery request and reply processes for a mobile node wherein these processes are implemented by a dynamic home agent discovery algorithm or system for a computer protocol.

[0030] Figure 4 is a diagram showing the home agent advertisement process for home agents used in a protocol that implements the present invention efficient dynamic home agent discovery algorithm and system.

[0031] Figure 5 is a diagram showing the home agent

discovery request and reply processes for a mobile node used in a protocol that implements the present invention efficient dynamic home agent discovery algorithm and system.

[0032] Figure 6 is a block diagram showing the home agent list and the list format maintained by each of the home agents used in the present invention efficient dynamic home agent discovery algorithm and system.

[0033] Figure 7 is a block diagram showing the heartbeat message and the message format wherein the message is communicated between the home agents for implementing the present invention efficient home agent discovery algorithm and system.

[0034] Figure 8 is a diagram showing broadcasting of heartbeat messages among the home agents.

[0035] Figure 9 is a block diagram of the registration reply extension used by home agents for the present invention efficient home agent discovery algorithm and system.

[0036] Figure 10 is a diagram illustrating a failure/error scenario and recovery therefrom by implementing the present invention efficient home agent discovery algorithm and system for the protocol.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENT

[0037] The present invention is an efficient and improved dynamic home agent discovery algorithm and system to be used in a protocol for Internet or network communications. The present efficient and improved dynamic home agent discovery algorithm and system for a protocol more efficiently uses the wireless access, communications resources, and the network resources.

If a failure or error occurs at a home agent 16, the efficient and improved dynamic home agent discovery algorithm and system provide recovery or backup home agent services to the mobile node(s) 11 associated or coupled to the failed home agent 16.

[0038] With reference now to the figures and in particular with reference to Figures 4 and 5, the present invention efficient dynamic home agent discovery algorithm and system simplify communication between the mobile node 11 and the home agents 16 generally to a single communication. The present invention efficient dynamic home agent discovery algorithm and system involve having the home agents 16 communicate to each other through internal or heart beat messages 20 and having each home agent 16 maintain a home agent list 26, which will be discussed later in this specification.

[0039] If multiple home agents 16 exist on the home link for the home network 12, a possibility of multiple home agents 16 sending agent advertisements within the same agent advertisement lifetime period exists as shown in Figure 2. The present efficient dynamic home agent discovery algorithm and system simplify the sending of agent advertisements from home agents 16 to the mobile node 11 to a single home agent advertisement

communication. With reference now to the figures and in particular with reference to Figure 4, a single home agent 16 is designated to send agent advertisements on behalf of the home agents 16 since the home agents 16 communicate with each other and each home agent 16 maintains a list 24 regarding all of the home agents 16 coupled to a home link for the home network 12. Therefore, the present efficient dynamic home agent discovery algorithm and system are implemented so that only a single home agent advertisement message is sent from the home network 12 and to the mobile node 11 as shown in Figure 4 in contrast to the prior art algorithms and systems that are implemented which require each and every home agent 16 in the home network 12 to send a home agent advertisement message to the mobile node 11 as shown in Figure 2.

[0040] Figure 3 shows that the mobile node 11 must send a home agent discovery request to each home agent 16 wherein the mobile node 11 sets the home agent subnet-directed broadcast address of the mobile node's home network 12 and sends the home agent discovery request to each home agent 16. The present efficient dynamic home agent discovery algorithm and system lets all of the home agents 16 receive the discovery request from the mobile node 11 through the broadcast message from the mobile node 11, but the algorithm and system simplify the reply from the home agents 16 by having only one home agent 16 process the request on behalf of the home network 12. With reference now to the figures and in particular with reference to Figure 6, a single home agent 16 is designated to receive and process the single home agent discovery or registration request from the mobile node 11 for itself and on behalf of the other home agents 16 since the home agents 16 communicate with each other and each home agent 16 maintains information and a list 24 regarding the other home agents 16. Therefore, the present efficient dynamic home agent discovery algorithm and system are implemented so that only a single home agent discovery or registration processes and replies to the request from the mobile node 11 for the home agents 16 as shown in Figure 5 in contrast to the prior art algorithms and systems that are implemented which require each and every home agent 16 in the home network 12 to process and reply to the home agent discovery request as shown in Figure 3.

[0041] Therefore, the present efficient dynamic home agent discovery algorithm and system have a single home agent 16 send advertisements for itself and for the other home agents 16. The mobile node 11 broadcasts a registration request communication to the home agents 16, including a designated home agent 16, and the designated home agent 16 for itself and for the other home agents 16 processes and sends a single registration reply communication to the mobile node 11. If a selected or designated home agent 16 fails, then another home agent 16 is selected or designated and takes over the operations of the failed home agent 16.

[0042] Each home agent 16 collects information about the other home agents 16 or its neighboring home agents 16, but only one home agent 16 responds to the dynamic home agent discovery request. With reference now to the figures and in particular with reference to Figure 6, the home agents 16 within the home network 12 are able to collect information by each maintaining a home agents list 24. The home agent list 24 comprises a storage array 26 that identify each of the home agents 16, a storage array 28 for indicating the life time for each of the home agents 16, and a storage array 30 for indicating the priority for selecting the respective home agent 16 as a selected or designated home agent 16.

[0043] The information (i.e. information in storage arrays 26, 28, and 30) contained in the home agent list 24 is obtained and learned from unsolicited heart beat messages 29 that are periodically sent by each home agent 16 serving on the link for the home network 12. The heart beat message 29 is a multicast message that is sent periodically by a home agent 16 to other home agents 16 in the same link for the home network 12. The message 29 contains various characteristic information of that home agent 16 to be broadcast to the other home agents 16.

[0044] The heart beat message 29 carries information about the home agent 16 that is transmitting or sending information. Figure 7 shows the fields of the heart beat message 29 sent or transmitted from a home agent 16 to be sent to and stored in the home agent lists 24 of other home agents 16. The fields for the heart beat message 29 include a type field 32, a priority field 33, a home agent IP address field 34, and a life time field 35. The type field 32 identifies the type of heart beat message 29 for the sending/transmitting home agent 16. The priority field 33 indicates the priority selection for that home agent 16. The home agent IP address field 34 contains the home agent IP address for the home agent 16. The life time field 35 identifies the life time of the home agent 16. Figure 8 shows a home agent 16 that is broadcasting heart beat messages 29 to each of the other home agents 16.

[0045] The selected or designated home agent 16 sends the home agent discovery reply on behalf of itself and the other home agents 16 in the home network 12. The single home agent discovery reply contains the registration reply extension 38. The registration reply extension 38 includes the IP addresses for all neighboring home agents 16 for which the selected or designated home agent 16 sends the home agent discovery reply. Figure 9 shows the fields of the registration reply extension 38. The registration reply extension 38 has a type field 39, a length field 40, and the home agent IP list field 42. The type field 38 identifies the type of reply message for each of the home agents 16 in the home agent list 24. The length field 40 indicates the length of each of the home agents 16 in the home agent list 24. The home agent IP list field 42 identifies and has the home agents 16 to which the designated or selected home agent 16

sends the registration reply

[0046] With reference now to the figures and in particular with reference to Figure 10, the present efficient dynamic home agent discovery algorithm and system allow another home agent 16 to be selected or designated according to a home agent priority if the selected or designated home agent 16 has failed. The priority is indicated in the home agent list 24 as shown in Figure 6. The newly selected or designated home agent 16 becomes responsible for agent advertising for itself and for the other home agents 16 in the home network 12 (i.e. in its home agent list 24) and for answering/responding to dynamic home agent discovery requests for itself and for the other home agents 16 in the home network 12 (i.e. in its home agent list 24).

[0047] Therefore, the present invention provides an efficient dynamic home agent discovery algorithm and system to be used in a protocol for Internet or network communications. The algorithm and system allow the protocol to more efficiently use the wireless access, communications resources, and the network resources. If a failure or error occurs at a home agent, the efficient and improved dynamic home agent discovery algorithm and system provide recovery or backup home agent services to the mobile node(s) associated or coupled to the failed home agent. Also, the present efficient home agent discovery algorithm and system are easily adapted to present home agent discovery algorithms and systems by simply implementing the home agent list, heart beat messages, and the registration reply extension.

[0048] While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

Claimo

1. An efficient dynamic home agent discovery algorithm used in a protocol method for managing and providing efficient communications and utilization of resources between a mobile node and home agents coupled to a home link, comprising the steps of:

encapsulating and integrating communications of the home agents into a single home agent communication, communicating the single home agent communication between the mobile node and the home agents, and performing dynamic home agent discovery processes based on the single home agent communication.

2. The efficient dynamic home agent discovery algorithm according to claim 1 wherein the encapsulation

ing step further comprises the step of:

having each of the home agents maintain a home agent list containing information about each of the home agents coupled to the home link wherein the information includes at least an internal protocol address of each of the home agents, remaining lifetimes relating to each of the home agents, and priority information relating to each of the home agents.

3. The efficient dynamic home agent discovery algorithm according to claim 2 further comprising the step of:
using heart beat messages to communicate the information between each of the home agents.
4. The efficient dynamic home agent discovery algorithm according to claim 3 further comprising the step of:
broadcasting the heart beat messages from one of the home agents to the other home agents.
5. The efficient dynamic home agent discovery algorithm according to claim 3 or 4 wherein the heart beat messages each further comprise a type field for indicating a type of the one of the home agents, a priority field for indicating a priority status of the one of the home agents, a home agent Internet protocol address field for indicating a home agent Internet protocol address of the one of the home agents, and a life time field for indicating a life time of the one of the home agents.
6. The efficient dynamic home agent discovery algorithm according to claim 1 wherein the encapsulating step further comprises the step of:
selecting a designated home agent to communicate on behalf of the home agents to the mobile node.
7. The efficient dynamic home agent discovery algorithm according to claim 6 wherein the selecting step further comprises the step of:
selecting the designated home agent based on a home agent priority policy.
8. The efficient dynamic home agent discovery algorithm according to claim 1 wherein the communicating step further comprises the step of:
communicating between the mobile node and a designated home agent wherein the designated home agent communicates with the other home agents and maintains a home agent list for communicating on behalf of the home agents coupled to the home link.
9. The efficient dynamic home agent discovery algorithm according to claim 8 wherein the step of com-

11

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12

municating between the mobile node and a designated home agent further comprises the step of:
 communicating a home agent discovery request from the mobile node to the designated home agent which receives the home agent discovery request.

10. The efficient dynamic home agent discovery algorithm according to claim 8 wherein the step of communicating between the mobile node and a designated home agent further comprises the step of:
 communicating a single home agent discovery reply from the designated home agent on behalf of the home agents to the mobile node.

11. The efficient dynamic home agent discovery algorithm according to claim 8 wherein the step of communicating between the mobile node and a designated home agent further comprises the step of:
 communicating a single home agent advertisement from the designated home agent on behalf of the home agents to the mobile node.

12. The efficient dynamic home agent discovery algorithm according to claim 1 wherein the performing step further comprises the step of:
 using a designated home agent on behalf of the home agents to receive and process a dynamic home agent discovery request from the mobile node.

13. The efficient dynamic home agent discovery algorithm according to claim 1 wherein the performing step further comprises the step of:
 using a designated home agent on behalf of the home agents to process and send a dynamic home agent discovery reply to the mobile node.

14. The efficient dynamic home agent discovery algorithm according to claim 13 wherein the dynamic home agent discovery reply further comprises a registration reply extension.

15. The efficient dynamic home agent discovery algorithm according to claim 14 wherein the registration reply extension further comprises a type field for indicating a type of the designated home agent, a length field for indicating a length of the designated home agent, and a home agent Internet protocol list field for indicating a list of the home agents coupled to the home link associated with the designated home agent.

16. The efficient dynamic home agent discovery algorithm according to claim 6 further comprising the steps of:
 determining if the designated home agent has

5 10 15 20 25 30 35 40 45 50 55

failed, and
 selecting a new designated home agent to communicate on behalf of the home agents if the designated home agent has failed.

17. An efficient dynamic home agent discovery system used in a protocol that manages and provides efficient communications and utilization of resources between a mobile node and home agents coupled to a home link, comprising:
 home agents that are encapsulated and integrated in communications with each other, and a designated home agent from the home agents to communicate and perform processes on behalf of the home agents to the mobile node.

18. The efficient dynamic home agent discovery system according to claim 17 further comprising:
 a home agent list maintained by each of the home agents wherein the home agent list contains information about each of the home agents coupled to the home link and wherein the information includes at least an Internet protocol address of each of the other home agents, remaining lifetime relating to each of the home agents, and priority information relating to each of the home agents.

19. The efficient dynamic home agent discovery system according to claim 17 wherein the designated home agent on behalf of the home agents receives and processes a home agent discovery request from the mobile node.

20. The efficient dynamic home agent discovery system according to claim 17 wherein the designated home agent on behalf of the home agents sends a single home agent advertisement and communicates and processes a single home agent discovery reply to the mobile node.

21. A computer program element comprising computer program code means to make a computer execute the algorithm as claimed in any one of claims 1 to 16.

22. A computer program element as claimed in claim 21, embodied on or in a computer readable medium.

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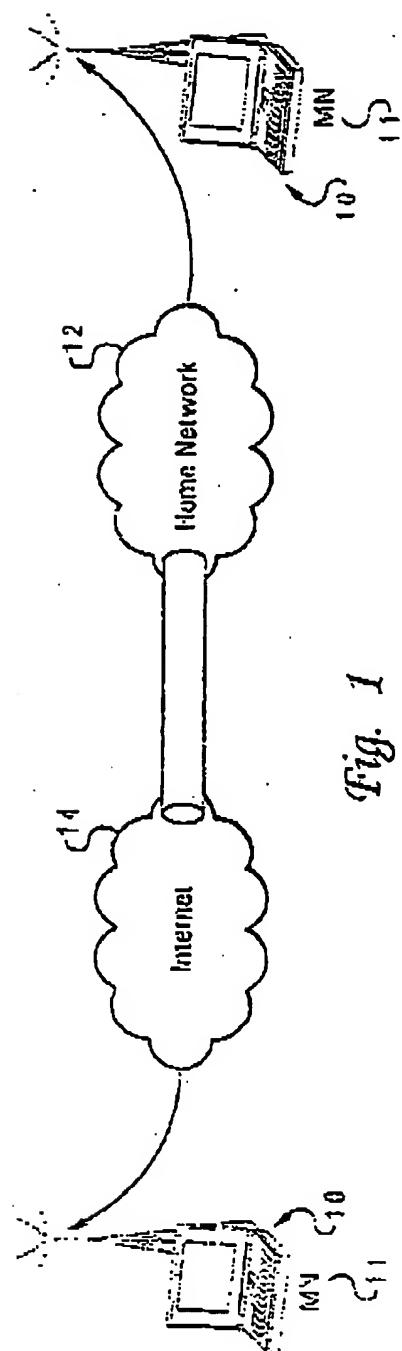


Fig. 1
Prior Art

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Home Agent Advertisement

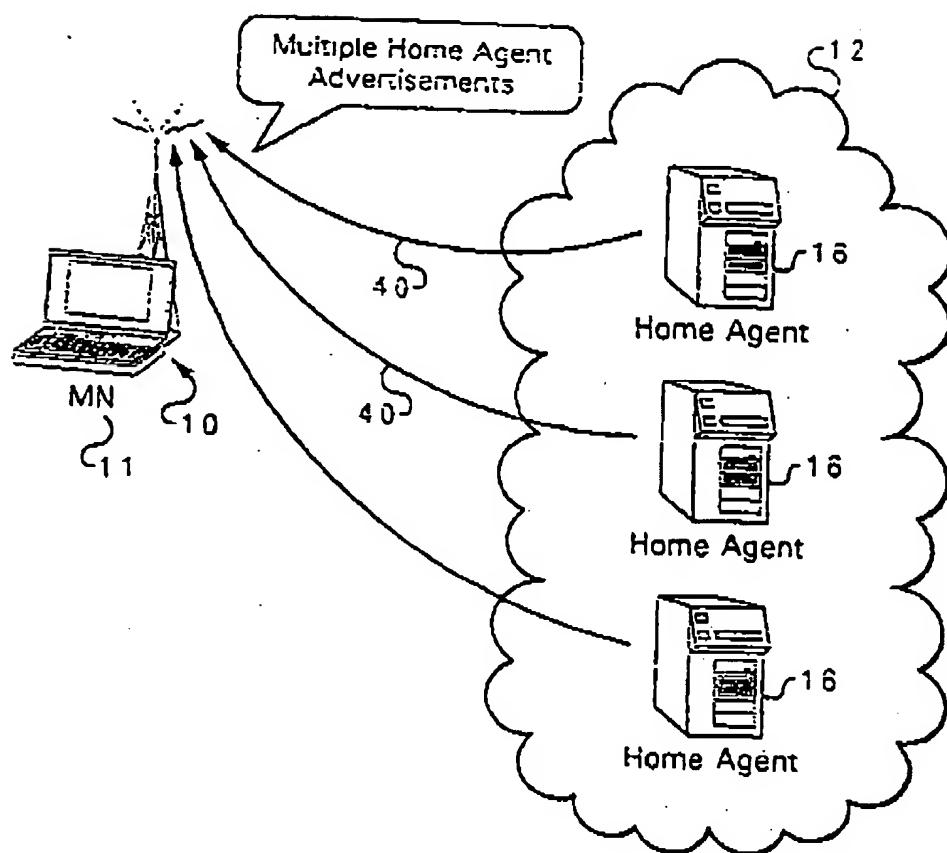


Fig. 2
Prior Art

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Dynamic Home Agent Discovery Process

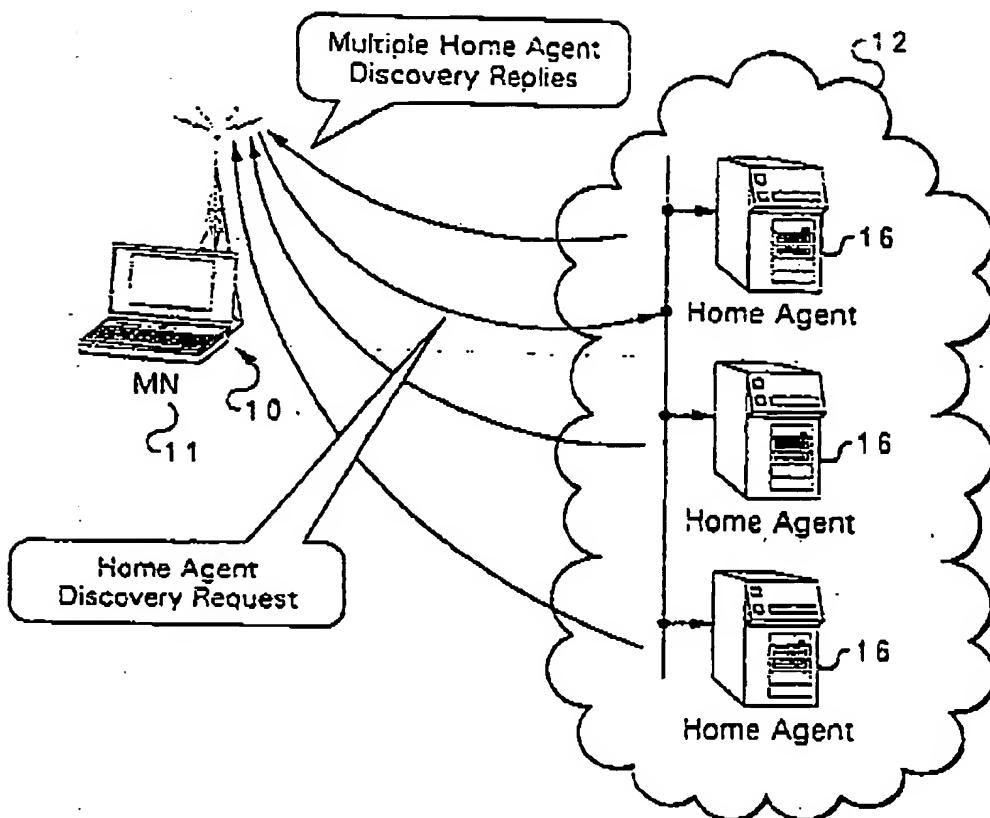


Fig. 3
Prior Art

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Home Agent Advertisement

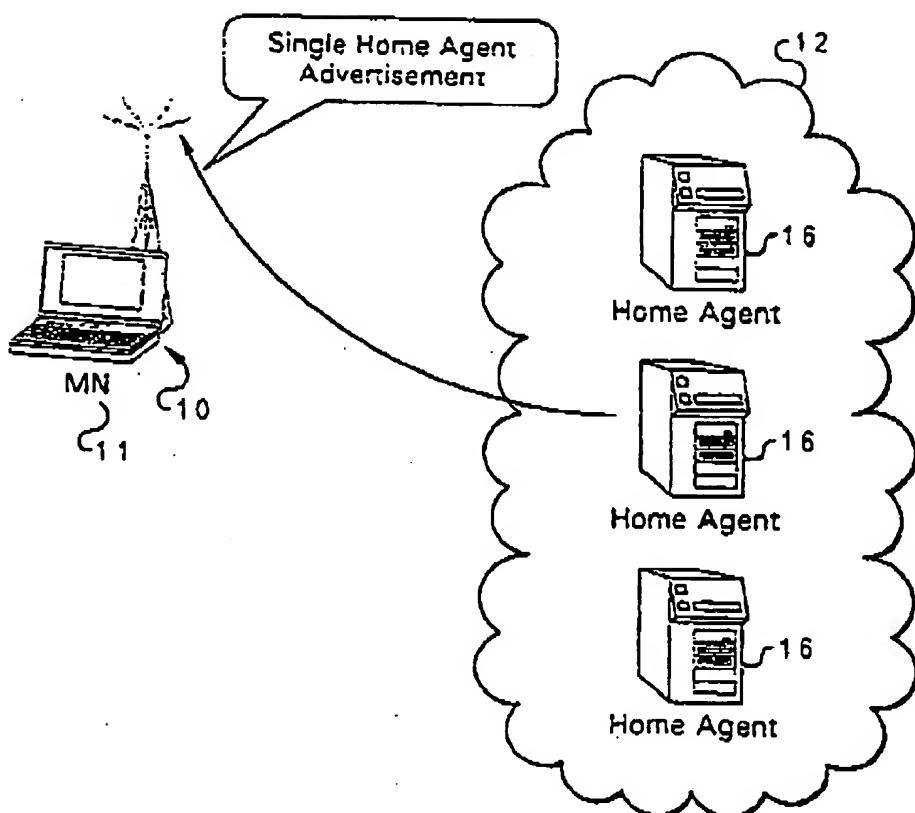


Fig. 4

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Dynamic Home Agent Discovery Process

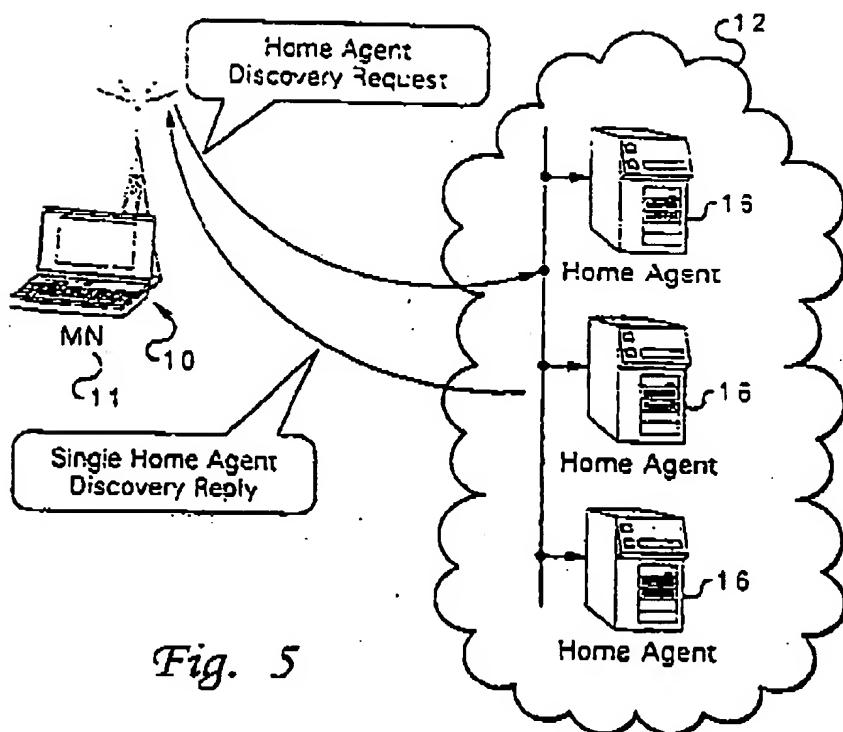


Fig. 5

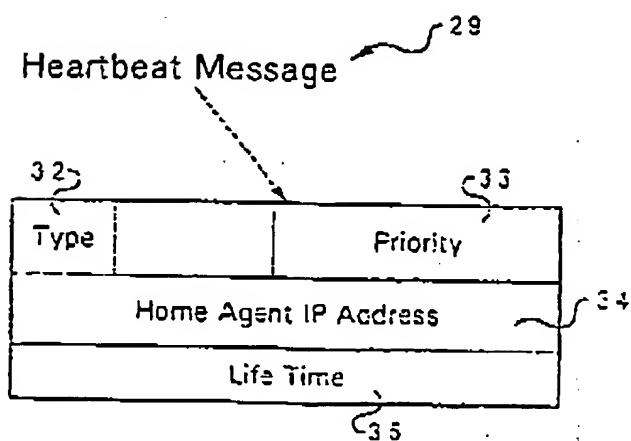


Fig. 7

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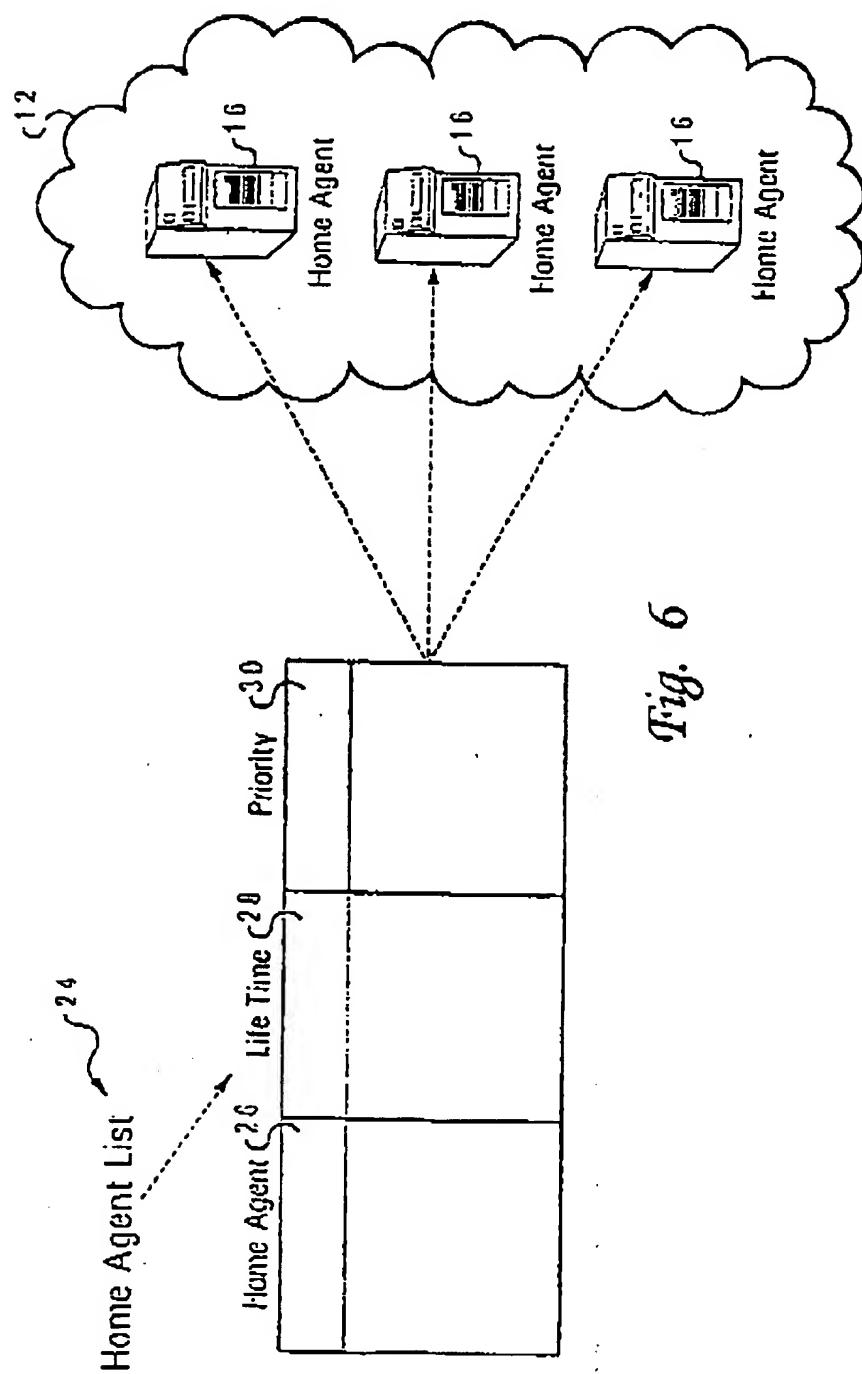


Fig. 6

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Broadcast Heartbeat Message

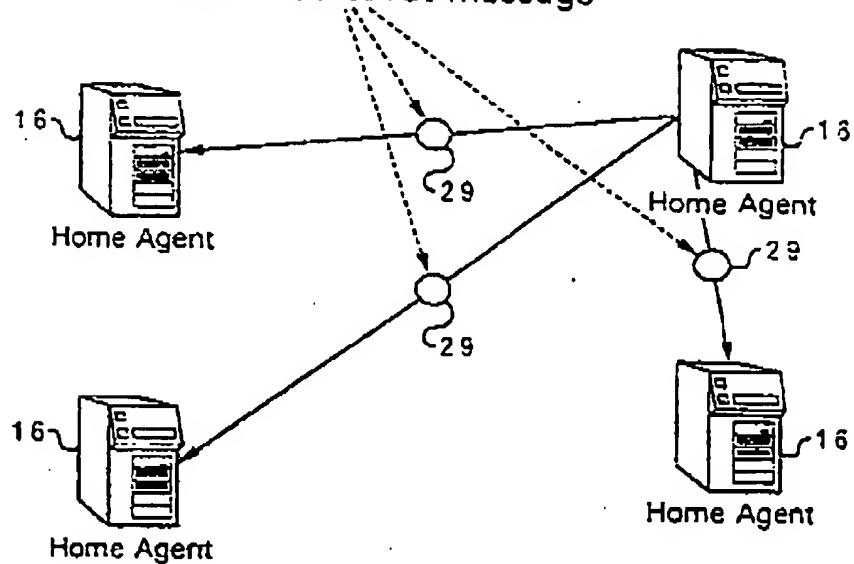


Fig. 8

Registration Reply Extension

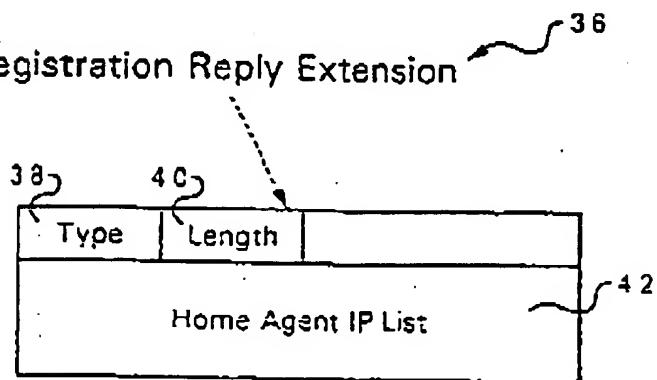
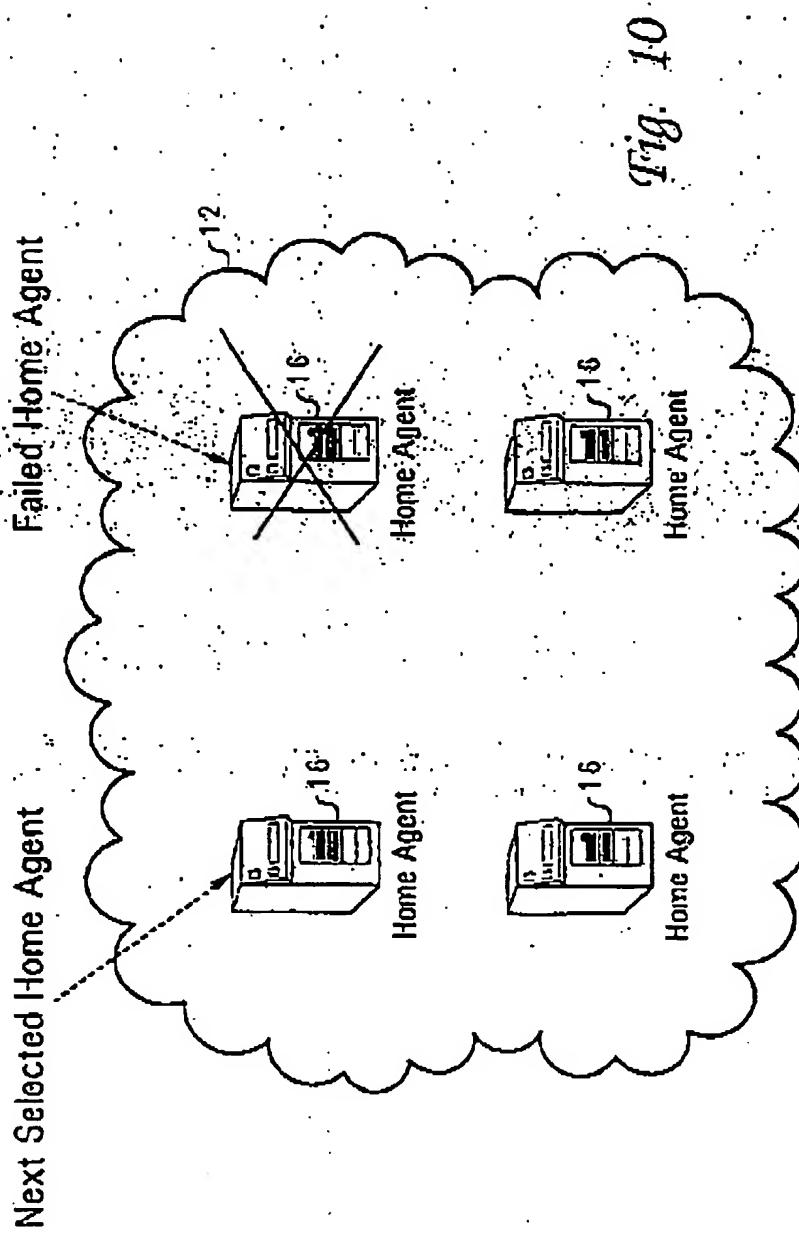


Fig. 9

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